

What We Claim Is:

1. A fuel rail assembly comprising:

a fuel rail having a longitudinal rail axis extending therethrough, the fuel rail having a fuel rail volume capable of receiving fuel; and

a fuel damper element disposed within the fuel rail and having a longitudinal damper element axis generally parallel to the longitudinal rail axis, the fuel damper element having a first portion and a second portion, the first portion includes a continuous surface having a series of undulations, and the second portion having a smooth surface. The fuel rail assembly of claim 1, wherein the first portion further comprises at least three points defining a virtual plane, the first portion including a continuous surface that intersects the virtual plane at three or more locations.

3. The fuel rail assembly according to claim 1, wherein the second portion includes a surface with a constant radius of curvature.

4. The fuel rail assembly according to claim 1, wherein the second portion includes a surface with a constant radius of curvature with respect to at least one of the longitudinal fuel rail axis and the longitudinal damper element axis.

5. The fuel rail assembly according to claim 1, wherein the first portion and a second portion are coupled together so as to define an outer surface and an inner surface, the inner surface enclosing a predetermined volume.

6. The fuel rail assembly according to claim 5, wherein the predetermined volume is sealed from fluid communication with the fuel rail volume.

7. The fuel rail assembly according to claim 5, wherein the first portion and the second portion comprise an integral member.

8. The fuel rail assembly according to claim 5, wherein the predetermined volume includes a predetermined volume of at least one of air and nitrogen.

- ✓ 9. The fuel rail assembly according to claim 1, wherein a cross section of the second portion being coupled to the first portion defines a closed two dimensional shape of at least three sides that touch only at their end points.
- ✓ 10. The fuel rail assembly according to claim 1, wherein the second portion includes at least three planar surfaces that are coupled to the first portion so as to define a predetermined volume.
- ✓ 11. The fuel rail assembly according to claim 1, wherein the continuous surface comprises obliquely stacked surfaces that form a corrugated surface across the virtual plane.
- ✓ 12. The fuel rail assembly according to claim 1, wherein the continuous surface comprises a plurality of planar surfaces oblique to the virtual plane and each planar surface is oblique to adjacent planar surfaces.
- ✓ 13. The fuel rail assembly according to claim 11, wherein the plurality of planar surfaces comprises a series of planar surfaces adjacent to one another such that every planar surface is parallel to every other planar surface in the series of planar surfaces.
- ✓ 14. The fuel rail assembly according to claim 1, wherein the continuous surface comprises a series of curved surfaces such that a cross section of the series of curved surfaces describes at least one curve approximating at least one function $y = a \cos^2 x$ and $y = a \sin^2 x$ as plotted over a coordinate plane where y is the amplitude of curve, x is a predefined interval and a is any real number.
- ✓ 15. A damper element for use in a fuel rail, the damper element comprising:
an elongated member having a longitudinal damper element axis generally parallel to the longitudinal rail axis, the elongated member having a first portion and a second portion, the first portion includes a continuous surface having a series of undulations, and the second portion having a smooth surface.

16. The damper element of claim 15, wherein the first portion further comprises at least three points defining a virtual plane, the first portion including a continuous surface that intersects the virtual plane at three or more locations.

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17. The damper element of claim 15, wherein the second portion includes a surface with a constant radius of curvature.

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18. The damper element of claim 15, wherein the second portion includes a surface with a constant radius of curvature with respect to at least one of the longitudinal fuel rail axis and the longitudinal damper element axis.

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19. The damper element of claim 15, wherein the first portion and a second portion are coupled together so as to define an outer surface and an inner surface, the inner surface enclosing a predetermined volume.

20. The damper element of claim 19, wherein the predetermined volume is sealed from fluid communication with the fuel rail volume.

21. The damper element of claim 19, wherein the first portion and the second portion comprise an integral member.

22. The damper element of claim 19, wherein the predetermined volume includes a predetermined volume of at least one of air and nitrogen.

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23. The damper element of claim 15, wherein a cross section of the second portion being coupled to the first portion define a close ended two dimensional shape of at least three sides that touch only at their end points.

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24. The damper element of claim 15, wherein the second portion includes at least three planar surfaces that are coupled to the first portion so as to define a predetermined volume.

25. The fuel rail assembly according to claim 15, wherein the continuous surface comprises obliquely stacked surfaces that form a corrugated surface across the virtual plane.

26. The fuel rail assembly according to claim 15, wherein the continuous surface comprises a plurality of planar surfaces oblique to the virtual plane.

27. The fuel rail assembly according to claim 26, wherein the plurality of planar surfaces comprises a series of planar surfaces adjacent to one another such that every planar surface is parallel to every other planar surface in the series of planar surfaces.

28. The fuel rail assembly according to claim 15, wherein the continuous surface comprises a series of curved surfaces such that a cross section of the series of curved surfaces describe at least one curve approximating at least one function $y = a \cdot \cos^* x$ and $y = a \cdot \sin^* x$ as plotted over a coordinate plane where y is the amplitude of curve, x is a predefined interval and a is any real number.

29. A method of damping pressure pulsations in a fuel injection system having a pressurized fuel source coupled to at least one fuel injector with a fuel rail establishing fluid communication between the pressurized fuel source and the at least one fuel injector, the fuel rail extending along an axis, the method comprising:

providing a fuel rail having a predetermined internal volume;

changing the predetermined internal volume of the fuel rail with placement of at least one damper element having a first portion and a second portion, the first portion includes a continuous surface having a series of undulations, and the second portion having a smooth surface.

30. The method of claim 29, wherein the changing further comprises changing a first internal volume of the at least one damper element in a first configuration to a second internal volume of the at least one damper element in a second configuration prior to placement of the at least one damper in the fuel rail.

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31. The method of claim 30, wherein the changing further comprises configuring a plurality of damper element, each damper element having at least one of a different internal volume and a different cross-sectional shape.

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32. The method of claim 30, wherein the first configuration includes an elongated tubular member.

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33. The method of claim 32, wherein the second configuration includes a member having a curvilinear surface of constant radius contiguous to a planar member whose surface is corrugated.

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34. The method of claim 30, wherein the changing further comprises preventing fluid communication between an exterior of the damper element and the second internal volume of the at least one damper element.